CHAETOGNATHS FROM THE ARCTIC BASIN, INCLUDING THE DESCRIPTION OF A NEW SPECIES OF *HETEROKROHNIA*

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INTRODUCTION

Four species of chaetognaths have been recorded from the Arctic Ocean; *Sagitta elegans, S. maxima, Eukrohnia hamata,* and an unspecified species of *Heterokrohnia*. *S. elegans* has been found most abundantly along the continental shelves and slopes of the Arctic Ocean (MacGinitie, 1955; Zenkevitch, 1963; Grainger, 1965) although it has been found over deep water adjacent to the slope (Bogorov, 1946; Brodsky and Nikitin, 1955; Mohr, 1959). *S. elegans* from these high latitudes may be represented by a separate subspecies *arctica* although the validity of this designation has been questioned by McLaren (1966). *S. maxima* has been recorded as occasionally present over deep water (Brodsky and Nikitin, 1955; MacGinitie, 1959; Dunbar and Harding (in press). *E. hamata* was considered to be an inhabitant of deep water by MacGinitie (1955) and Zenkevitch (1963). Zenkevitch (1963) considered this species as one of a group of zooplankters that indicate the presence of North Atlantic water in the Arctic Basin despite the fact that MacGinitie (1955) found several reproducing specimens near Pt. Barrow, Alaska. Other records of *E. hamata* by Bogorov (1946, Grainger (1965), and Cairns (1967) show that this species can be found, in smaller numbers, over the continental slope and shelf. *Heterokrohnia* was listed from over deep water of the Canada Basin by Dunbar and Harding (in press).

The opportunity to add to the existing information on chaetognaths of the Arctic Basin was provided by collections made from Fletcher's Ice Island T-3 as it drifted over a mainly deep water area between September 1965 and September 1966. This collection is particularly valuable as the thirteen consecutive months of collecting allow for a better understanding not only of the species present, but of changes in vertical distribution and reproductive condition through the year.

Methods and Materials

Specimens used in the study were collected from Fletcher's Ice Island T-3 by Alan J. Mearns from September 1965 to January 1966, Gary P. Owen from February 1966 to May 1966, and the author from June 1966 to September 1966. During this 13 month period the ice island drifted from 75°21′N, 140°53′W in the Canada Basin to 75°42′N, 160°58′W in the Chukchi Sea. Collecting was carried out through a meter-square hole in the sea ice adjacent to the ice island. A list of stations at which chaetognaths were collected will be deposited with the American Documentation Institute, Library of Congress, Washington, D. C. Closing nets with a one-half meter opening and mesh of No. 6, 20 or 24 were used for vertical tows and No. 6 and 20 non-closing nets for horizontal tows. A small biological trawl (Menzies, 1962) modified by the removal of the supporting frame except that portion which held the mouth open was used for taking a small number of bottom samples. Most samples were preserved in 7 per cent formalin buffered with hexamethylenamine, but some were preserved in Bouin's fluid or in 70 per cent ethanol. Hydrographic data was provided by the University of Washington and areal positions as well as bottom depths by Lamont Geological Observatory.

Only specimens 8 mm and greater in length were removed from the samples and identified with the exception of the new species of *Heterokrohnia* in which all specimens were removed. Measurements of tail and total lengths excluding the tail fin were obtained by placing the chaetognath on a millimeter scale in water. Samples preserved in Bouin's or alcohol sometimes were bent or shrunken and this reduced the accuracy of measurements of chaetognaths to approximately ± 0.5 mm. For *Eukrohnia hamata,* in addition to measuring total length and tail length, the number of teeth and hooks were counted. Specimens of *E. hamata* were grouped in various maturity stages according to the classification of Kramp (1939) which is as follows:

STAGE	MALE GONADS	FEMALE GONADS
I	Unripe	Unripe
II	Tail containing more or less sperm	All eggs small
III	Sperm evacuated	All eggs small, seminal receptacle filled with sperm
IV	Sperm evacuated	Ovaries filled with ripe eggs
V	Sperm evacuated	Eggs evacuated, receptacle still contained sperm

Results

Four species, one of which is new, belonging to three genera were collected. These were *Eukrohnia hamata, Sagitta maxima, Heterokrohnia mirabilis,* and *Heterokrohnia* n. sp. . None of the *Eukrohnia* sufficiently satisfied the characteristics of *E. bathypelagica* (Alvariño, 1962) and thus all were identified as *E. hamata*. Probably the most trenchant differentiating characteristic between *E. hamata* and *E. bathypelagica* is the per cent tail length to total length. Alvariño's (1962) figure 22 shows the clearly separate linear relationships of tail to total lengths of both species. None of the tail to total length data from this collection follows the *E. bathypelagica* regression line and most of the data do follow the line of *E. hamata* although there is a good deal of variance as the animals increase in size.

Eukrohnia hamata (Mobius, 1875)

Eukrohnia hamata was the most abundant of the chaetognaths in this collection with 1159 specimens from 155 hauls, accounting for 97 percent of the chaetognaths collected. Most of the specimens were juveniles, but all stages of sexual maturity were represented; 1056 juvenile, 64 stage I, 16 stage II, 1 stage III, 7 stage IV, and 15 stage V.

In each of the maturity stages from I to V total length, per cent tail to total length, number of hooks, and number of teeth are considered (Table 1). The total lengths of the animals show the most marked changes between stage I and II. Ranges and means for total lengths in stages II and IV are about the same. The single individual from stage III was not included as its tail was badly damaged. The apparent decrease in the length of stage IV, which corresponds with the ripening of the eggs, may be an artifact resulting from shrinkage of different degrees and from measuring a small number of specimens of a wide range of sizes. The per cent tail to total length shows a gradual increase to stage IV with a marked increase from stage IV to V. There is a decrease in the mean number of hooks to stage III, but an increase in the subsequent stages. If the decrease is real, it seems that this could occur only if the older and larger hooks dropped off as the animal aged. The number of teeth present is most variable and has the lowest value in stage I. Variation is less in subsequent stages which, with the exception of the single specimen from stage III, have a fairly constant mean value.

The vertical distribution of mature and immature *Eukrohnia hamata* (Fig. 1) shows the mature *E. hamata* descending to a depth greater than 3000 meters in the month of June with the bottom limit ascending slowly through the rest of the summer. During the descent of mature individuals there were no specimens from stages III to V collected at depths of less

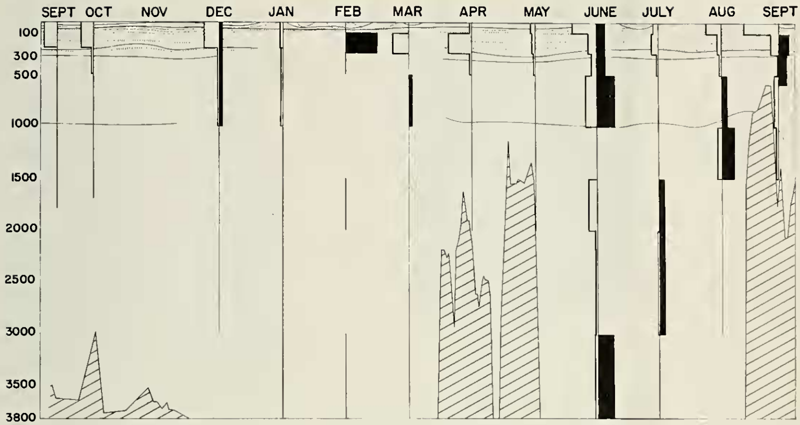

Figure 1. Distribution of adult and juvenile *Eukrohnia hamata*. Depth in meters on left. Bottom indicated by hatched area. Dotted lines represent salinity contours and on the left from top to bottom they are 30.0, 31.0, 32.0, 33.0, 34.0 0/00. Solid horizontal lines represent temperature contours and on the left from top to bottom they are −1.4, −1.4, −0.6, +0.2, +0.2°C. Open boxes represent the number of immature (juvenile and stage I) caught per 250 meter vertical tow, and darkened boxes represent ten times the number of mature (stage II-V) caught per 250 meter vertical tow. Vertical lines represent the depth of water which was sampled in each month.

than 500 meters, and only in the latter part of the summer, i.e. September, were stage V individuals collected at less than 500 meters.

During the general warming of summer the surface −1.6°C isotherms disappear but the deeper temperature layers remain stable. There appears to be a general decline in the number of *E. hamata* caught in the 300 to 500 meter interval, which is the interval with the most rapid temperature change as well as that with highest temperature (up to +0.6°C) in the Canada Basin. The salinity remains fairly constant with the exception of the surface salinity which is diluted by the summer fresh water runoff. The greatest numbers of adult and juvenile *E. hamata* were collected during the summer (June-September) in deep water and in the upper 100 meters respectively, while during winter there was a decline in the number of mature and immature individuals at these levels.

All of the 13 chaetognaths in stage V possess a marsupium formed by the folding upward and inward of the lateral fins, and two of the 13 contain young in an eggsack (Fig. 2A and B). These two latter specimens are from station 93 (Dawson), a horizontal tow at a depth of 500 meters made on August 16, 1966, and station 124 (Dawson), a 600-300 meter vertical tow made on September 7, 1966. Several of the remaining stage V specimens still possess remnants of the eggsack which contained the

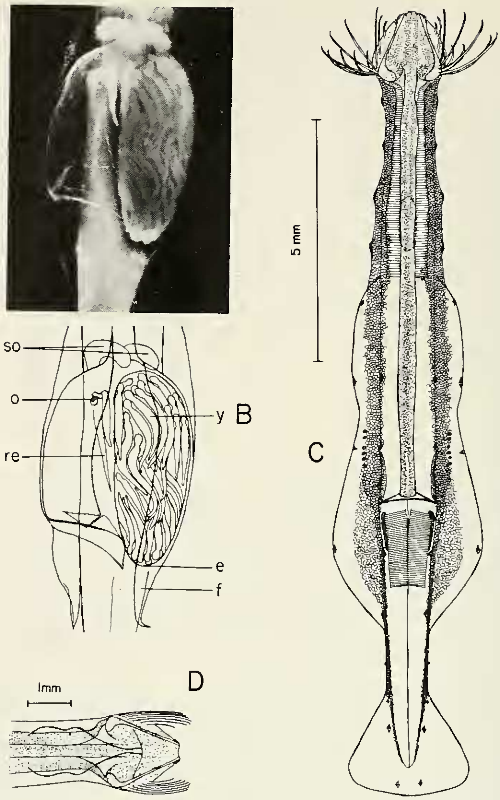

Figure 2. A and B. Marsupium and eggsack of *Eukrohnia hamata.* A. Photomicrograph; B. Diagram of photomicrograph; e — eggsack; f — folded fin; o — oviduct opening; re — ruptured eggsack; so — spent ovaries; y — young; C. Dorsal view of *Heterokrohnia involucrum* n. sp. Fin rays not shown; D. Dorsal view of *Heterokrohnia involucrum* n. sp. Head showing ciliary loop.

young while being held by the parent. Two eggsacks develop adjacent to each other with each eggsack being in communication with its respective oviduct opening by a fine tubule. Both specimens of this collection however possess only one intact eggsack with the other adjacent sack being ruptured previously in the discharge of young or broken in the collecting procedure. In the case of the specimen from station 124, one young remained in the eggsack even though it was ruptured. The specimen from station 93 contains young in an undeveloped, curled state, but the young being held by the animal from station 124 are well developed with identifiable heads, bodies, and guts. The more developed young are quite uniform in size; approximately 2.4 mm long. All but the most posterior young are oriented with their anterior end toward the anterior end of the eggsack. One *E. hamata* collected by Rey Stendell off East Greenland, which was not a part of the year's collecting, was also examined. This individual still possessed both eggsacks filled with well developed young. There were about 50 young to each side or a total of 100 young. This chaetognath was taken April 19, 1965 at 68°55′N, 20° 35′W in a vertical closing net tow from 1100 to 900 meters.

Sagitta maxima (Conant, 1896)

Twenty-three *Sagitta maxima* were collected from 20 hauls. *S. maxima* was caught throughout the year and at various depths. They ranged in size from 8 to 54 mm and all were immature.

Heterokrohnia mirabilis Ritter-Záhony, 1911

All of the seven *Heterokrohnia mirabilis* were found in three bottom trawls and they ranged in size from 7 to 20 mm. Four of the seven specimens were mature. Since bottom trawls are pulled to the surface with the mouth of the net open, it is possible that *H. mirabilis* may have been collected in mid-water. However, their absence in plankton hauls suggests that they were collected at or very close to the bottom.

Heterokrohnia involucrum n. sp.

Ten specimens of a new species of *Heterokrohnia, Heterokrohnia involucrum* were collected in five separate tows (Table 2). The trivial name is from the Latin involucrum meaning sheath or covering. In the case of *Heterokrohnia involucrum* the sheath or covering refers to the collarette covering the length of the body. The five specimens from station 58 were twisted and shrunken from being preserved in ethanol and consequently their measurements are least accurate. All specimens were immature. The holotype and paratypes are deposited at the Allan Hancock Foundation, University of Southern California under the chaetognath catalog number 68-1.

The main differentiating characteristic between *H. involucrum* and the closely related *H. mirabilis* and *H. bathybia* Marumo and Masataka (1966) is that the new species has a very large long foamy collarette covering the entire length of the body while *H. mirabilis* has no collarette and *H. bathybia* has a collarette extending only from the head to halfway between the head-trunk septum and the anterior end of the ventral ganglion. Because most of the specimens are immature, it is difficult to compare the hook and teeth number of *H. involucrum* with that of *H. mirabilis* and *H. bathybia*. The lateral fins are similar to those of *H. mirabilis* and unlike those of *H. bathybia*. Due to the presence of the large collarette, the neck is not as conspicuous as that of *H. mirabilis.* The head is also not as large in the new species as it is in *H. mirabilis* or *H. bathybia* and the body appears more transparent when preserved in buffered formalin than is the case with *H. mirabilis.*

The holotype (Fig. 2C) is the most mature of the 10 individuals, having clearly visible developing ovaries. It was collected in a horizontal tow at 3800 meters (bottom depth 3845M) with a No. 6 mesh non-closing net at 75°37′N, 153°57′W. The total length of the holotype is 15.7mm excluding tail fin and the tail segment is 35.0% of the total length. On each side, the numbers of hooks are 11-11; anterior teeth are 12-14; and the posterior are 25-25.

Tangoreceptors are present along the length of the body and fins. Transverse muscles extend from the neck to the anterior edge of the lateral fins and from close to the trunk-tail septum to about one-third the length of the tail section. The lateral fins originate approximately half way between the head-trunk and trunk-tail septa and extend to the midposition between the trunk-tail septum and tip of the tail. The lateral fins narrow about one-third of the distance from their anterior edge and then become wider in the posterior two-thirds. The tail fin is spade shaped and all fins are completely rayed, although these rays have not been included in fig. 2C. The ciliary loop was seen in a paratype specimen fixed in Bouin's solution, (Fig. 2D). Glandular canals are present along the dorsolateral margin of the head with a gland reservoir at the tip of the head. The hooks are very similar to those of *H. mirabilis* with the major curvature being at the anterior end of the hooks. The teeth are the same as those of *H. mirabilis* in Ritter-Záhony's (1911) fig. 47, with the anterior teeth short and flat and the posterior teeth longer and thin. No gut diverticulum is present and eyes are lacking, both characteristic of the genus *Heterokrohnia.* The collarette begins at the head and extends the length of the animal. Between the head and origin of the lateral fins the collarette is thick with a distinct outer border. At the lateral fin area, the dorsal and ventral parts of the collarette retain the smooth outer border but on the lateral fins the collarette spreads out with no distinct borders. At the trunk-tail septum area of the fins a very fine collarette spreads out further on the fins and the heavier collarette narrows to be relatively thin, continuing narrow until the tail fin is reached. At the tail fin the collarette becomes very fine and continues so to the tip of the tail.

Discussion

The evidence that *Eukrohnia hamata* descends into deep water during the summer months to breed is fairly well agreed upon by various chaetognath workers. In Greenland waters Kramp (1939) found that young *E. hamata* at the surface start to descend into deeper water as they mature and continue this downward movement while the female organs are developing. Breeding then takes place in the deep water which is evidenced by stages III-V being found only at depths greater than 500 meters, with some of the young returning to the surface. He believes that this breeding may occur throughout the year with a maximum in summer and autumn. In Norwegian waters, however, Wiborg (1954) found breeding to take place in April and May. David (1958b) believes that the migration to the deep may be "a behavioral relic of some deep-living ancestral form" and because there are fewer barriers to deep forms relative to surface types, then the dispersal of the species may have been by way of the deep living forms. Generally during the downward migration of summer the more mature stages of *E. hamata* are found at depths greater than 500 meters. David (1958b) collected only stage III and IV below 750 meters but specimens of stage V (var. *antarctica*) were found at the surface as well as in deep water.

In Norwegian waters, Wiborg (1954) found the greatest number of *E. hamata* in the spring and summer with peaks in May and July. There are several factors which could result in the increased yield of young *E. hamata* (Fig. 2) collected at the surface during the 13 month sampling period. The most likely factor seems to be the restocking of copepod nauplii, following the phytoplankton bloom, which is a probable food source for the young chaetognath during the summer. However, other factors could be involved, such as a preference for the lower salinity caused by the fresh water runoff from the ice or the presence of continuous light in the upper water layers. The absence of immature *E. hamata* in the upper 100 meters during the winter could be the result of the reverse or lack of any of the above mentioned factors. Both the presence of young at the surface in the summer and the absence of young at the surface in the winter show a lag behind the above factors of a month or so, which would be expected.

The presence of a marsupium containing an eggsack is a characteristic unique to the genus *Eukrohnia*. It has been reported several times in the past literature to occur in *Eukrohnia hamata*. Nordgaard (1805) was the first person to describe the marsupium with an eggsack. "In samples from the Vest Fjord (300-400m, 500-600m) there were specimens with eggbags. The hinderpart of the side fin was bent downward, thus forming a hollow in which the eggs lay tightly pressed together." A similar *E. hamata* from the "Belgica" collection was described by Ritter-Záhony (1910). This specimen was 30 mm in length and from a depth of 750-900 meters. He describes the change in the side fins which provide the

TABLE 1

Eukrohnia hamata. Total and per cent tail length; hook and teeth number of the maturity stages.

STAGE	TOTAL LENGTH (mm)		PER CENT TAIL LENGTH (mm)		HOOK NUMBER		TEETH NUMBER	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
I	17-31	24.9	20-33	24.3	9-11	9.7	13-30	19.3
II	24-35	30.4	21-27	24.9	8-10	9.3	20-30	23.0
III					8-9	8.5	20-21	20.5
IV	23-31	26.7	23-31	26.1	8-9	8.6	22-24	22.5
V	27-35	30.2	27-35	30.2	8-11	8.9	20-29	23.0

marsupium for the eggsack as well as the plum shape jelly-like sacks which contain the eggs. An excellent drawing of the marsupium and eggsack is shown on his plate V, figure 17. Kuhl (1928) states that in the genus *Eukrohnia,* the eggs are not set free but are pasted by a jelly-like cementing substance to a kind of "eggsack" and that this egg packet is carried around under the lateral fins by the parental animal in the region of the trunk-tail septum of the back. MacGinitie (1955) caught two *E. hamata* in a surface tow at Point Barrow, Alaska in which he described young escaping from a marsupium formed by the folding up of the lateral fins. Ruptured eggsacks have been found in *Eukrohnia fowleri* by Tchindonova (1955) as indicated by David (1958b), and David (1958b) has found an egg-shaped opaque structure at the opening of the oviduct on a specimen of *Eukrohnia bathyantarctica.* Both the ruptured eggsacks and the eggshaped opaque structure were attached to the chaetognath by a fine tubule which went directly into the oviduct, and David (1958b) concluded that the ruptured eggsack represented a later stage of development of the opaque egg-shaped structure. He believed that the opaque egg-shaped structure may have been seminal vesicles which had been transferred from the tail segment of one animal to the oviduct of another. The vas deferens which transferred the sperm from the tail segment into the seminal vesicles may then be the tubule which enters the oviduct and provides the pathway for the sperm to enter the oviduct.

E. hamata is considered by David (1958b) to be a classic example of an organism with bipolar distribution, with *E. hamata* being at the surface or epipelagic layers in the cold polar waters and in the meso- and bathypelagic layers in the tropical and equatorial regions. *Sagitta maxima* appears to be sparsely distributed in the Canada Basin of the Arctic

TABLE 2

Measurements and number of hooks and teeth of the new species *Heterokrohnia involucrum*

STATION	TOTAL LENGTH mm	PERCENT TAIL LENGTH	NUMBER HOOKS	NUMBER ANTERIOR TEETH**	NUMBER POSTERIOR TEETH**	TYPE OF TOW	DEPTH OF TOW (M)	BOTTOM DEPTH (M)
102 (Mearns)*	11.2	37.5	10-10	11-10	16-18	Vertical	3000-1960	3800
19 (Dawson)	15.7	35.0	11-11	14-12	25-25	Horizontal	3800	3845
58 (Dawson)*	5.5	32.8	7-7			Horizontal	2500	3835
58 (Dawson)*	6.0	33.3	8-9	4-4	12-12	Horizontal	2500	3835
58 (Dawson)*	6.0	33.3	8-9			Horizontal	2500	3835
58 (Dawson)*	7.0	38.6	8-7	7-7	17-18	Horizontal	2500	3835
58 (Dawson)*	7.2	38.9	8-8	6-7	17-17	Horizontal	2500	3835
86 (Dawson)	9.5	31.6	9-10	8-8	17-17	Vertical	3800-0	3840
142 (Dawson)	13.3	34.6	10-11	10-10	21-21	Vertical	1800-1200	1809
142 (Dawson)	13.5	34.8	11-11	12-12	23-25	Vertical	1800- 200	1809

* Specimens preserved in 70% ethanol. All others preserved in 7% buffered formalin.

** In specimens smaller than 10 mm the teeth count may be an approximation because of the difficulty in seeing the exact number.

Ocean and it is considered by Alvariño (1965) to be a cosmopolitan meso- or deep oceanic species extending from the Arctic-Subarctic to the Antarctic-Subantarctic regions. *Heterokrohnia mirabilis* seems to be a relatively rare species in the world oceans. It was considered by David (1959) to be an endemic antarctic species, but Bieri (1959) has also found *H. mirabilis* in the Pacific-Central American region and Tchindonova (1955) found a single specimen in the Kurile-Kamchatka region.

Heterokrohnia involucrum does not appear to be limited to any particular depth since this new species was collected throughout the water column. Nine of the ten specimens were collected during the summer, a fact which may be of some significance. *H. involucrum* may be an endemic species of the Arctic Ocean since this species has been found nowhere else, but since the main characteristic differentiating *H. involucrum* from *H. mirabilis* is the presence of a collarette, mishandled specimens could be stripped of their collarette and consequently be identified as *H. mirabilis*.

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Summary

During a year's sampling in the Canada Basin of the Arctic Ocean four species of chaetognaths were collected; *Eukrohnia hamata, Sagitta maxima, Heterokrohnia mirabilis,* and *H. involucrum* n. sp. . The most abundant was *Eukrohnia hamata* which had seasonal changes in the vertical distribution of the maturity stages; with a downward movement in the summer to deep water. Two *Eukrohnia hamata* carrying young in a marsupium were collected and these along with other *E. hamata* possessing a marsupium but no young are described.

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